

# Modernizing national geodetic networks: Some experiences in Africa

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## 1. SUMMARY

The United Nations has adopted a resolution affirming the importance of geodesy in sustainable development, encouraging member states to strengthen and maintain national geodetic infrastructure and to have a modern, accurate, and universally accessible reference system. Various GNSS systems now allow for accuracies on the order of a few millimetres. Thanks to these systems, geodesy, the mathematical determination of the Earth's shape, provides cartographers and planners with increasingly precise reference points.

The rehabilitation of a country's geodetic network is therefore fundamental to its development and forms the necessary foundation for a wide range of sectors, including land management, land security, urban planning, sanitation, transportation, border management, and national security.

In Africa, 2 recent projects, implemented by IGNFI and geodetic experts from IGN (French mapping agency), in Uganda and in Senegal highlighted the challenges: long term sustainability, relationships between private sector and geodetic government agencies, support to stakeholders, skill transfers and technical challenges due to change of reference systems.

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## 2. INTRODUCTION

At the national level, the goal is to modernize the national geodetic network by installing new permanent GNSS stations (CORS), integrating existing stations (both public and private), and upgrading existing physical network points. This network of stations distributed across the national territory constitutes a new national reference system and is linked to the international system.

Uganda and Senegal have chosen to launch this modernization and update of their geodetic infrastructure by seeking the expertise of IGN FI.

Implementing this modern, reliable, and precise geodetic reference framework across the entire country, supports land administration and spatial planning, then providing funding from both international and national agencies

These countries now have a modernized geodetic network, tied to the international ITRF system, ensuring consistency in practices among users and coherence for all professionals involved.

Skills transfer and change management are key priorities. These projects can only succeed with the strong involvement of local stakeholders, users, and network managers. Furthermore, establishing a sustainable business model is essential to ensure the long-term viability of the equipment and services implemented.

This article presents the modernization of geodetic networks recently carried out in Uganda and Senegal and highlights strategic perspectives for guaranteeing the sustainability of the systems put in place.

## 3. MODERNIZATION OF NATIONAL GEODETIC NETWORKS IN UGANDA AND SENEGAL

The implementation of a new, modern geodetic reference network relies on the installation of permanent reference stations (CORS), the rehabilitation of the existing physical geodetic network still in use, and the establishment of a geodetic database.

Uganda and Senegal are part of this initiative, with the modernization of their respective networks carried out by IGN FI.

In Uganda, 40 permanent stations were installed with two project phases from 2017 to 2020 and from 2023 to 2025. 40 private stations were also integrated into the network. In addition, 426 1<sup>st</sup> and 2<sup>nd</sup> order network markers were rehabilitated, surveyed, and calculated.

In Senegal, an initial network of 16 stations was implemented from 2023 to 2026, also integrating existing public and private CORS stations. The 139 points of the 1<sup>st</sup> and 2<sup>nd</sup> order networks have also been rehabilitated and calculated in the new reference.

The CORS station networks constitute the zero-level network, and their construction adheres to international standards governed by the IGS and UNAVCO. These CORS stations are in constant communication with a control center. This center centralizes data to ensure quality control before the data (both in Rinex files and in RTCM streaming format) is released to users. Online post-processing and coordinate transformation calculations are also implemented as a service to users. The goal is to provide users with reliable, accurate, and, above all, consistent data within the coverage area of these stations. These control centers are equipped with servers, storage components, and security tools to ensure 24/7 operational service.

The implementation of a geodetic database, incorporating the development of a GIS mapping interface and the establishment of a secure web portal, enables the provision of all geodetic data and its metadata.

#### **4. ESTABLISHING THE NEW REFERENCE SYSTEM**

GNSS data processing is performed using the CORS network, initially calculated with reference to IGS stations. The coordinates are then expressed in the latest ITRF realization. Historical physical networks are also calculated in this reference frame, followed by a transformation calculation in the country's original reference frame, incorporating velocity models.

In Uganda and Senegal, this processing of permanent stations data was carried out using the Bernese scientific software, and then the coordinates of the 1<sup>st</sup> and 2<sup>nd</sup> order networks were fitted to their respective CORS networks.

Implementing a new reference system is always a challenge for a country and its user community. To discuss the advantages and risks of adopting a new reference system, discussions were held with the technical committees established for each project. Uganda and Senegal chose their reference systems: in Uganda, the new UGRF reference system was thus

retained; in Senegal, the historical 20-year old ITRF-based RRS04 network was conserved. These choices are motivated by the absence of a modern reference system in Uganda, and for Senegal, the need to maintain internal consistency with the numerous historical documents, without compromising the consistency and accuracy of the new CORS network, or the relative accuracy of the entire national network.

## **5. SUSTAINABILITY OF THE NETWORKS ESTABLISHED AND PROSPECTS**

### Skills Transfer

No network can be implemented without comprehensive and well-considered local support to ensure its sustainability.

First and foremost, skills transfer is essential to ensure the effective management and control of the network configuration in each country.

This transfer takes place from the outset of each project, involving individuals designated by the network managers. Their participation extends to all active phases of the project, and they receive targeted training on the operation and administration of the various components of the tool. Subsequently, the gradual integration of users into infrastructure development complements the expertise established within the national territory.

### Prospects and Business Model

The denser the networks of permanent stations, the better the coverage for users. This is why Uganda chose to continue the project with a Phase 2, which enabled nationwide coverage with 28 new stations. The resulting network provides complete coverage and redundancy in the most urbanized areas. Senegal began this work with a first phase, which will need to be completed to achieve full national coverage. Private stations are also integrated into the network. The continued integration of private stations must be strongly considered and will require a public-private partnership, essential for the operation and maintenance of national networks.

Furthermore, establishing a business model is essential to ensure the sustainability of the equipment and services implemented. This business model must incorporate a strategic and innovative approach, guarantee high-precision positioning services, and ensure financial viability to meet growing service needs and serve the interests of all stakeholders.

The business model for the network of permanent stations must be based on collaborative management and integrate the needs of both public and private stakeholders. Free periods and pricing conditions must be established through a gradual and collaborative approach, highlighting the necessity of the services while strengthening user trust.

## 6. CONCLUSION

The modernization of national geodetic networks addresses the growing need for geospatial services. The networks of permanent stations, an integral part of this modernization, incorporate current best practices in technological innovation.

The modernized networks of Uganda and Senegal are becoming essential infrastructure for supporting land-use planning and stimulating the country's economic and strategic development.

Work is underway to define a viable economic model. The governance and management structure to be implemented must clearly define responsibilities to effectively manage and support network expansion and maintenance, while ensuring that national priorities are met, thereby strengthening national sovereignty.

## REFERENCES

## BIOGRAPHICAL NOTES

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